WO 98/31772
PCT/US98/01195

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES

(PCT Rule 47.1(c), first sentence)

To:
MINNICH, Richard, J.
Fay, Sharpe, Beall, Fagan, Minnich
& McKee
7th floor
1100 Superior Avenue
Cleveland, OH 44114-2518
ETATS-UNIS D'AMERIQUE

Date of mailing (day/month/year) 23 July 1998 (23.07.98)	
Applicant's or agent's file reference CWR 2 242 PCT	**IMPORTANT NOTICE**

International application No.	**International filing date** (day/month/year)	**Priority date** (day/month/year)
PCT/US98/01195	21 January 1998 (21.01.98)	21 January 1997 (21.01.97)

Applicant
CASE WESTERN RESERVE UNIVERSITY et al

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:
   BR,CA,CN,EP,IL,JP,KP,KR,NO,PL,US

   In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:
   AL,AP,BA,BB,BG,CU,CZ,EA,EE,GE,GH,GM,GW,HU,ID,IS,LC,LK,LR,LT,LV,MG,MK,MN,MX,NZ,OA, RO,SG,SI,SK,SL,TR,TT,UA,UZ,VN,YU,ZW

   The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on
   23 July 1998 (23.07.98) under No. WO 98/31772

REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, **a demand for international preliminary examination** must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the **national phase**, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer
J. Zahra

Telephone No. (41-22) 338.83.38

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

United States Patent and Trademark Office
(Box PCT)
Crystal Plaza 2
Washington, DC 20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 13 August 1998 (13.08.98)	
International application No. PCT/US98/01195	**Applicant's or agent's file reference** CWR 2 242 PCT
International filing date (day/month/year) 21 January 1998 (21.01.98)	**Priority date** (day/month/year) 21 January 1997 (21.01.97)
Applicant PETSCHEK, Rolfe, G. et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

15 July 1998 (15.07.98)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Eugénia Santos
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/01195

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :Please See Extra Sheet.
US CL :252/299.4, 299.01; 428/1

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 252/299.4, 299.01; 428/1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4,068,923 A (TOIDA) 17 January 1978 (17-01-78).	1-20
A	US 4,965,017 A (HOLMES ET AL) 23 October 1990 (23-10-90).	1-20
Y,P	US 5,639,398 A (RHEE ET AL) 17 June 1997 (17-06-97), column 3, lines 50-58, column 5, lines 1-60.	1, 9, 10, 16, 17

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search
07 APRIL 1998

Date of mailing of the international search report
07 MAY 1998

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3230

Authorized officer
CYNTHIA H. KELLY
Telephone No. (703) 308-0661

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/01195

A. CLASSIFICATION OF SUBJECT MATTER:
IPC (6):

CO9K 19/56, 19/52, 19/00

RECEIVED

APR 22 1998

FAY, SHARPE, BEALL, FAGAN, MINNICH & McKEE

PATENT COOPERATION TREATY

PCT

From the INTERNATIONAL BUREAU

To:

MINNICH, Richard, J.
Fay, Sharpe, Beall, Fagan, Minnich
& McKee
7th floor
1100 Superior Avenue
Cleveland, OH 44114-2518
ETATS-UNIS D'AMERIQUE

NOTIFICATION CONCERNING SUBMISSION OF PRIORITY DOCUMENTS

(PCT Administrative Instructions, Section 411)

Date of mailing (day/month/year) 08 April 1998 (08.04.98)	
Applicant's or agent's file reference CWR 2 242 PCT	IMPORTANT NOTIFICATION

International application No.	International filing date (day/month/year)	Priority date (day/month/year)
PCT/US98/01195	21 January 1998 (21.01.98)	21 January 1997 (21.01.97)

Applicant

CASE WESTERN RESERVE UNIVERSITY et al

The applicant is hereby notified of the date of receipt by the International Bureau of the priority document(s) relating to the following application(s):

Priority application No:	Priority date:	Priority country:	Date of receipt of priority document:
60/034,966	21 Jan 1997 (21.01.97)	US	07 Apr 1998 (07.04.98)

"DOCKETED"

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer Christelle Crocl Telephone No.: (41-22) 338.83.38

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
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BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference
(if desired) (12 characters maximum)

Box No. I TITLE OF INVENTION

BUFF-FREE LIQUID CRYSTAL ALIGNMENT USING POLY(IONOMER) COATINGS

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

CASE WESTERN RESERVE UNIVERSITY
10900 Euclid Avenue
Cleveland, Ohio 44106
US

☐ This person is also inventor.

Telephone No.
(216) 368-4286

Facsimile No.
(216) 368-5481

Teleprinter No.

State *(i.e. country)* of nationality:
US

State *(i.e. country)* of residence:
US

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

PETSCHEK, Rolfe G.
2866 Woodbury Road
Shaker Heights, Ohio 44120
US

This person is:
☐ applicant only
☒ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality:
US

State *(i.e. country)* of residence:
US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

MINNICH, Richard J.
Fay, Sharpe, Beall, Fagan, Minnich & McKee
1100 Superior Avenue; Seventh Floor
Cleveland, Ohio 44114-2518
US

Telephone No.
(216) 861-5582

Facsimile No.
(216) 241-1666

Teleprinter No.
fsb@faysharpe.com

☐ Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Sheet No. 2

Continuation of Box No. III FURTHER APPLICANTS AND/OR (FURTHER) INVENTORS

If none of the following sub-boxes is used, this sheet is not to be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

HARRISON, Daniel
3244 East Fairfax Road
#3
Cleveland Heights, Ohio 44118
US

This person is:
- [ ] applicant only
- [X] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: US

State *(i.e. country)* of residence: US

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [X] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

FISCH, Michael
17437 Edgewater Drive
Lakewood, Ohio 44107
US

This person is:
- [ ] applicant only
- [X] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: US

State *(i.e. country)* of residence: US

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [X] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

This person is:
- [ ] applicant only
- [ ] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality:

State *(i.e. country)* of residence:

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [ ] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

This person is:
- [ ] applicant only
- [ ] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality:

State *(i.e. country)* of residence:

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [ ] the United States of America only
- [ ] the States indicated in the Supplemental Box

- [ ] Further applicants and/or (further) inventors are indicated on another continuation sheet.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked)*:

Regional Patent

- [x] AP ARIPO Patent: GH Ghana, KE Kenya, LS Lesotho, MW Malawi, SD Sudan, SZ Swaziland, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- [x] EA Eurasian Patent: AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- [x] EP European Patent: AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- [x] OA OAPI Patent: BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line)*:

- [x] AL Albania
- [ ] AM Armenia
- [ ] AT Austria
- [x] AU Australia
- [ ] AZ Azerbaijan
- [x] BA Bosnia and Herzegovina
- [x] BB Barbados
- [x] BG Bulgaria
- [x] BR Brazil
- [ ] BY Belarus
- [x] CA Canada
- [ ] CH and LI Switzerland and Liechtenstein
- [x] CN China
- [x] CU Cuba
- [x] CZ Czech Republic
- [ ] DE Germany
- [ ] DK Denmark
- [x] EE Estonia
- [ ] ES Spain
- [ ] FI Finland
- [ ] GB United Kingdom
- [x] GE Georgia
- [x] GH Ghana
- [x] HU Hungary
- [x] IL Israel
- [x] IS Iceland
- [x] JP Japan
- [ ] KE Kenya
- [ ] KG Kyrgyzstan
- [x] KP Democratic People's Republic of Korea
- [x] KR Republic of Korea
- [ ] KZ Kazakstan
- [x] LC Saint Lucia
- [x] LK Sri Lanka
- [x] LR Liberia
- [ ] LS Lesotho
- [x] LT Lithuania
- [ ] LU Luxembourg
- [x] LV Latvia
- [ ] MD Republic of Moldova
- [x] MG Madagascar
- [x] MK The former Yugoslav Republic of Macedonia
- [x] MN Mongolia
- [ ] MW Malawi
- [x] MX Mexico
- [x] NO Norway
- [x] NZ New Zealand
- [x] PL Poland
- [ ] PT Portugal
- [x] RO Romania
- [ ] RU Russian Federation
- [ ] SD Sudan
- [ ] SE Sweden
- [x] SG Singapore
- [x] SI Slovenia
- [x] SK Slovakia
- [x] SL Sierra Leone
- [ ] TJ Tajikistan
- [ ] TM Turkmenistan
- [x] TR Turkey
- [x] TT Trinidad and Tobago
- [x] UA Ukraine
- [ ] UG Uganda
- [x] US United States of America
- [x] UZ Uzbekistan
- [x] VN Viet Nam
- [x] YU Yugoslavia
- [x] ZW Zimbabwe

Check-boxes reserved for designating States (for the purposes of a national patent) which have become party to the PCT after issuance of this sheet:

- [x] GM Gambia (AP)
- [x] GW Guinea-Bissau
- [x] ID Indonesia
- [ ] .....
- [ ] .....

In addition to the designations made above, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except the designation(s) of _____.
The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. ***(Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)***

Box No. VI PRIORITY CLAIM Further priority claims are indicated in the Supplemental Box ☐

The priority of the following earlier application(s) is hereby claimed:

Country *(in which, or for which, the application was filed)*	Filing Date *(day/month/year)*	Application No.	Office of filing *(only for regional or international application)*
item (1) US	(21.01.1997) 21 January 1997	60/034,966	
item (2) US	(25.06.1997) 25 June 1997	60/050,765	
item (3)			

Mark the following check-box if the certified copy of the earlier application is to be issued by the Office which for the purposes of the present international application is the receiving Office (a fee may be required):

☒ The receiving Office is hereby requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s): 1 and 2

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(If two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):* ISA / US

Earlier search *Fill in where a search (international, international-type or other) by the International Searching Authority has already been carried out or requested and the Authority is now requested to base the international search, to the extent possible, on the results of that earlier search. Identify such search or request either by reference to the relevant application (or the translation thereof) or by reference to the search request:*

Country (or regional Office): Date *(day/month/year)*: Number:

Box No. VIII CHECK LIST

This international application contains the following number of sheets:

1. request	:	4 sheets
2. description	:	11 sheets
3. claims	:	3 sheets
4. abstract	:	1 sheets
5. drawings	:	1 sheets
Total	:	20 sheets

This international application is accompanied by the item(s) marked below:

1. ☒ separate signed power of attorney Two (2)
2. ☐ copy of general power of attorney
3. ☐ statement explaining lack of signature
4. ☐ priority document(s) *identified in Box No. VI as item(s):*
5. ☒ fee calculation sheet
6. ☐ separate indications concerning deposited microorganisms
7. ☐ nucleotide and/or amino acid sequence listing (diskette)
8. ☒ other *(specify)*: Transmittal Form PTO-1382

Figure No. _____ of the drawings (if any) should accompany the abstract when it is published.

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

21 January 1998
Date

Richard Minnich
MINNICH, Richard J.

For receiving Office use only

1. Date of actual receipt of the purported international application:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:
4. Date of timely receipt of the required corrections under PCT Article 11(2):
5. International Searching Authority specified by the applicant: ISA /
6. ☐ Transmittal of search copy delayed until search fee is paid

2. Drawings:
☐ received:
☐ not received:

For International Bureau use only

Date of receipt of the record copy by the International Bureau:

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference CWR 2 242PCT	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/US98/01195	International filing date *(day/month/year)* 21 JANUARY 1998	Priority date *(day/month/year)* 21 JANUARY 1997
International Patent Classification (IPC) or national classification and IPC IPC(6): C09K 19/56, 19/52, 19/00 and US Cl.: 252/299.4, 299.01; 428/1		
Applicant CASE WESTERN RESERVE UNIVERSITY		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 3 sheets.

   ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority. (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 1 sheets.

3. This report contains indications relating to the following items:

   I ☒ Basis of the report

   II ☐ Priority

   III ☐ Non-establishment of report with regard to novelty, inventive step or industrial applicability

   IV ☐ Lack of unity of invention

   V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

   VI ☐ Certain documents cited

   VII ☐ Certain defects in the international application

   VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
15 JULY 1998	22 SEPTEMBER 1998
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer CYNTHIA HARRIS KELLY Telephone No. (703) 308-0661

Form PCT/IPEA/409 (cover sheet) (January 1994)*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US98/01195

I. Basis of the report

1. This report has been drawn on the basis of (*Substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments*):

[X] the international application as originally filed.

[X] the description, pages 1-11 , as originally filed.
pages NONE , filed with the demand.
pages NONE , filed with the letter of _____.
pages _____ , filed with the letter of _____.

[X] the claims, Nos. 1-20 , as originally filed.
Nos. NONE , as amended under Article 19.
Nos. NONE , filed with the demand.
Nos. NONE , filed with the letter of _____.
Nos. _____ , filed with the letter of _____.

[X] the drawings, sheets/~~fig~~ 1 , as originally filed.
sheets/~~fig~~ NONE , filed with the demand.
sheets/~~fig~~ NONE , filed with the letter of _____.
sheets/~~fig~~ _____ , filed with the letter of _____.

2. The amendments have resulted in the cancellation of:

[X] the description, pages NONE.

[X] the claims, Nos. NONE.

[X] the drawings, sheets/~~fig~~ NONE.

3. [ ] This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the ~~Supplemental Box~~ Additional observations below (Rule 70.2(c)).

4. Additional observations, if necessary:

NONE

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US98/01195

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. STATEMENT

Novelty (N)	Claims	1-20	YES
	Claims	NONE	NO
Inventive Step (IS)	Claims	1-20	YES
	Claims	NONE	NO
Industrial Applicability (IA)	Claims	1-20	YES
	Claims	NONE	NO

2. CITATIONS AND EXPLANATIONS

ClaimS 1-20 meet the criteria set out in PCT Article 33(2)-(4), because the prior art does not teach or fairly suggest the coating composition which has a charged poly(ionomer) and a solvent or the process of manufacturing a buff-free liquid crystal display using the coating composition. The instant invention meets the industrial applicability criteria as it finds use as a coating composition.

---------- NEW CITATIONS ----------

NONE

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

PCT

To:

RICHARD J. MINNICH
FAY, SHARPE, BEALL, FAGAN & MINNICH
1100 SUPERIOR AVE.
7TH FL.
CLEVELAND OH 44114-2518

AUG 0 5 1998

FAY, SHARPE, BEALL, FAGAN, MINNICH & McKEE

NOTIFICATION OF RECEIPT OF DEMAND

(PCT Rule 61.1(b), first sentence and Administrative Instructions, Section 601)

Date of mailing (day/month/year) 28 JUL 1998

Applicant's or agent's file reference	IMPORTANT NOTIFICATION	
CWR 2 242PCT		
International application No. PCT/US98/01195	International filing date (day/month/year) 21 JAN 98	Priority date (day/month/year) 21 JAN 97

Applicant
CASE WESTERN RESERVE UNIVERSITY

1. The applicant is hereby notified that this International Preliminary Examining Authority considers the following date as the date of receipt of the demand for international preliminary examination of the international application:

IPEA/US 15 JUL 1998

2. This date of receipt is:

☑ the actual date of receipt of the demand.

☐ the date on which the proper corrections to the demand were timely received.

3. ☐ This date is **AFTER** the expiration of 19 months from the priority date.

Attention: The election(s) made in the demand does (do) not have the effect of postponing the commencement of the national phase until 30 months from the priority date (or later in some Offices) (Article 39(1)). Therefore, the acts for entry into the national phase must be performed within 20 months from the priority date (or later in some Offices) (Article 22).

For details, see Annex B to Form PCT/IB/301 sent by the International Bureau and Volume II of the PCT Applicant's Guide.

☐ This notification confirms the information given in person or by telephone on:

_____

4. Only where paragraph 3 applies, a copy of this notification has been sent to the International Bureau.

Name and mailing address of the IPEA/US	Authorized officer
Assistant Commissioner for Patents Box PCT Washington, D.C. 20231 Attn: IPEA/US Facsimile No.	Yolanda V. Harrod PCT/International Appl Processing Div Telephone No. (703) 305-3670

Form PCT/IPEA/402 (July 1992)

PATENT COOPERATION TREATY

RECEIVED
OCT 14 1998
FAY, SHARPE, BEALL, FAGAN, MINNICH & McKEE

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To: RICHARD J. MINNICH
FAY, SHARPE, BEALL, FAGAN AND MINNICH & MCKEE
1100 SUPERIOR AVENUE
SEVENTH FLOOR
CLEVELAND, OH 44114-2518

PCT

NOTIFICATION OF TRANSMITTAL OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of Mailing *(day/month/year)*	09 OCT 1998
Applicant's or agent's file reference: CWR 2 242PCT	IMPORTANT NOTIFICATION

International application No.	International filing date *(day/month/year)*	Priority Date *(day/month/year)*
PCT/US98/01195	21 JANUARY 1998	21 JANUARY 1997

Applicant
CASE WESTERN RESERVE UNIVERSITY

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices)(Article 39(1))(see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Authorized officer CYNTHIA H. KELLY
Facsimile No. (703) 305-3230	Telephone No. (703) 308-0661

Form PCT/IPEA/416 (July 1992)★

"DOCKETED"

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference CWR 2 242PCT	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/US98/01195	International filing date *(day/month/year)* 21 JANUARY 1998	Priority date *(day/month/year)* 21 JANUARY 1997
International Patent Classification (IPC) or national classification and IPC IPC(6): C09K 19/56, 19/52, 19/00 and US Cl.: 252/299.4, 299.01; 428/1		
Applicant CASE WESTERN RESERVE UNIVERSITY		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 3 sheets.

   ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority. (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 1 sheets.

3. This report contains indications relating to the following items:

   I ☒ Basis of the report

   II ☐ Priority

   III ☐ Non-establishment of report with regard to novelty, inventive step or industrial applicability

   IV ☐ Lack of unity of invention

   V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

   VI ☐ Certain documents cited

   VII ☐ Certain defects in the international application

   VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
15 JULY 1998	22 SEPTEMBER 1998
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer CYNTHIA HARRIS KELLY Telephone No. (703) 308-0661

Form PCT/IPEA/409 (cover sheet) (January 1994)★

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US98/01195

I. Basis of the report

1. This report has been drawn on the basis of (*Substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments*):

[X] the international application as originally filed.

[X] the description, pages 1-11 , as originally filed.
pages NONE , filed with the demand.
pages NONE , filed with the letter of _____.
pages _____ , filed with the letter of _____.

[X] the claims, Nos. 1-20 , as originally filed.
Nos. NONE , as amended under Article 19.
Nos. NONE , filed with the demand.
Nos. NONE , filed with the letter of _____.
Nos. _____ , filed with the letter of _____.

[X] the drawings, sheets/~~fig~~ 1 , as originally filed.
sheets/~~fig~~ NONE , filed with the demand.
sheets/~~fig~~ NONE , filed with the letter of _____.
sheets/~~fig~~ _____ , filed with the letter of _____.

2. The amendments have resulted in the cancellation of:

[X] the description, pages NONE.

[X] the claims, Nos. NONE.

[X] the drawings, sheets/~~fig~~ NONE.

3. [ ] This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the ~~Supplemental Box~~ Additional observations below (Rule 70.2(c)).

4. Additional observations, if necessary:
NONÉ

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US98/01195

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. STATEMENT

Novelty (N)	Claims	1-20	YES
	Claims	NONE	NO
Inventive Step (IS)	Claims	1-20	YES
	Claims	NONE	NO
Industrial Applicability (IA)	Claims	1-20	YES
	Claims	NONE	NO

2. CITATIONS AND EXPLANATIONS

ClaimS 1-20 meet the criteria set out in PCT Article 33(2)-(4), because the prior art does not teach or fairly suggest the coating composition which has a charged poly(ionomer) and a solvent or the process of manufacturing a buff-free liquid crystal display using the coating composition. The instant invention meets the industrial applicability criteria as it finds use as a coating composition.

---------- NEW CITATIONS ----------

NONE

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

RECEIVED

MAY 0 9 1998 PCT

FAY, SHARPE, BEALL, FAGAN, MINNICH & McKEE

To: RICHARD J. MINNICH
FAY, SHARPE, BEALL, FAGAN AND MINNICH & MCKEE
1100 SUPERIOR AVENUE
SEVENTH FLOOR
CLEVELAND, OH 44114-2518

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

	Date of Mailing *(day/month/year)* 07 MAY 1998
Applicant's or agent's file reference CWR 2 242PCT	FOR FURTHER ACTION See paragraphs 1 and 4 below
International application No. PCT/US98/01195	International filing date *(day/month/year)* 21 JANUARY 1998
Applicant CASE WESTERN RESERVE UNIVERSITY	

1. [X] The applicant is hereby notified that the international search report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:
The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the international search report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. [ ] The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. [ ] **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

[ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

[ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in rules 90 *bis* 1 and 90 *bis* 3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 "DOCKETED" Facsimile No. (703) 305-3230	Authorized officer CYNTHIA H. KELLY Telephone No. (703) 308-0661

Form PCT/ISA/220 (January 1994)★ *(See notes on accompanying sheet)*

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference CWR 2 242PCT	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
International application No. PCT/US98/01195	International filing date *(day/month/year)* 21 JANUARY 1998	(Earliest) Priority Date *(day/month/year)* 21 JANUARY 1997
Applicant CASE WESTERN RESERVE UNIVERSITY		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. [ ] **Certain claims were found unsearchable** (See Box I).

2. [ ] **Unity of invention is lacking** (See Box II).

3. [ ] The international application contains disclosure of a **nucleotide and/or amino acid sequence listing** and the international search was carried out on the basis of the sequence listing
   - [ ] filed with the international application.
   - [ ] furnished by the applicant separately from the international application,
     - [ ] but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.
   - [ ] transcribed by this Authority.

4. With regard to the **title**,
   - [X] the text is approved as submitted by the applicant.
   - [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,
   - [X] the text is approved as submitted by the applicant.
   - [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is:
   Figure No. _____
   - [ ] as suggested by the applicant.
   - [ ] because the applicant failed to suggest a figure.
   - [ ] because this figure better characterizes the invention.
   - [X] None of the figures.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/01195

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :Please See Extra Sheet.
US CL :252/299.4, 299.01; 428/1

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 252/299.4, 299.01; 428/1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4,068,923 A (TOIDA) 17 January 1978 (17-01-78).	1-20
A	US 4,965,017 A (HOLMES ET AL) 23 October 1990 (23-10-90).	1-20
Y,P	US 5,639,398 A (RHEE ET AL) 17 June 1997 (17-06-97), column 3, lines 50-58, column 5, lines 1-60.	1, 9, 10, 16, 17

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 07 APRIL 1998	Date of mailing of the international search report 0 7 MAY 1998
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer CYNTHIA H. KELLY Telephone No. (703) 308-0661

Form PCT/ISA/210 (second sheet)(July 1992)★

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/01195

A. CLASSIFICATION OF SUBJECT MATTER:
IPC (6):

C09K 19/56, 19/52, 19/00

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : C09K 19/56, 19/52, 19/00 — A1

(11) International Publication Number: **WO 98/31772**

(43) International Publication Date: 23 July 1998 (23.07.98)

(21) International Application Number: PCT/US98/01195

(22) International Filing Date: 21 January 1998 (21.01.98)

(30) Priority Data:

60/034,966	21 January 1997 (21.01.97)	US
60/050,765	25 June 1997 (25.06.97)	US

(71) Applicant *(for all designated States except US)*: CASE WESTERN RESERVE UNIVERSITY [US/US]; 10900 Euclid Avenue, Cleveland, OH 44106 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: PETSCHEK, Rolfe, G. [US/US]; 2866 Woodbury Road, Shaker Heights, OH 44120 (US). HARRISON, Daniel [US/US]; 3244 East Fairfax Road #3, Cleveland Heights, OH 44118 (US). FISCH, Michael [US/US]; 17437 Edgewater Drive, Lakewood, OH 44107 (US).

(74) Agent: MINNICH, Richard, J.; Fay, Sharpe, Beall, Fagan, Minnich & McKee, 7th floor, 1100 Superior Avenue, Cleveland, OH 44114–2518 (US).

(81) Designated States: AL, BA, BB, BG, BR, CA, CN, CU, CZ, EE, GE, GH, GM, GW, HU, ID, IL, IS, JP, KP, KR, LC, LK, LR, LT, LV, MG, MK, MN, MX, NO, NZ, PL, RO, SG, SI, SK, SL, TR, TT, UA, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: BUFF–FREE LIQUID CRYSTAL ALIGNMENT USING POLY(IONOMER) COATINGS

(57) Abstract

The present invention consists of materials and a processing method for coating rigid–rod poly(ionomers) or salts thereof, in a solvent system, directionally on charged surfaces resulting in the formation of liquid crystal display surfaces with planar alignment and pretilt.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

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BUFF-FREE LIQUID CRYSTAL ALIGNMENT USING POLY(IONOMER) COATINGS

This application claims priority to the filing dates of U.S. Provisional Application No. 60/034,966, filed January 21, 1997 and U.S. Provisional Application No. 60/050,765, filed June 25, 1997.

Field of the Invention

The present invention is directed to liquid crystal materials and a process for preparing a liquid crystal display. More specifically, the invention is directed to coating rigid-rod poly(ionomers), or salts thereof, directionally on charged surfaces resulting in the formation of surfaces with planar alignment and pretilt.

Background of the Invention

Nematic, Smectic C and other liquid crystal devices are routinely used in display applications. They are also used in a variety of other devices, such as variable retarders and laser stabilizers, to control light. Most such devices require alignment layers, that is, layers on the surface of transparent electrodes which cause the special axes of the liquid crystal to align in a specific direction relative to the electrode surface.

The literature concerning liquid crystal displays is vast. The popular book "Liquid Crystals: Nature's Delicate Phase of Matter" by Peter Collings (Princeton Science Library, ©1990) is a readable introduction to the subject and is incorporated herein by reference.

Rubbed polyimides and polyimide-amides are the "standard" material used in the liquid crystal industry today for manufacturing liquid crystal displays. Rubbed nylon 6-6 and rubbed Teflon® are also known and used in liquid crystal research. However, there are few

commercial uses in the liquid crystal industry for these types of alignment layers.

Rubbing, more commonly referred to as buffing, is a technique used to align liquid crystal material deposited onto the surface of a liquid crystal display. In practicing this buffing technique, thin coatings of a long chain polymer are applied to the facing surfaces of the two transparent plates between which the liquid crystal layer is disposed. By subsequently rubbing these coatings with a soft material such as cotton cloth or paper, the molecules on the respective coatings can be oriented so that the long axes of the liquid crystal molecules adjacent the respective plates will align parallel to the rubbing direction. This technique, however, has several inherent disadvantages. First, the rubbing operation introduces unwanted contamination onto the polymer coatings because the materials which are used to rub the polymer are generally something other than the polymer itself. For example, cotton or paper are commonly used to rub or buff the polymeric liquid crystals into the desired alignment. Unwanted contaminants from the paper or cotton buffing medium may remain on the liquid crystal surface after the buffing is complete or may contaminate clean-room manufacturing facilities. Second, the rubbing operation introduces considerable shearing forces on the polymer film and may tear the film away from the substrate during manufacture.

Further, buffing generates static electricity which may modify or destroy the underlying active matrix (transistor array) in certain displays. It is also rather ill controlled and depends on a number of poorly understood parameters such as the exact nature of the rubbing cloth, the processing of the polyimide, the humidity of the manufacturing plant, etc. A significant difficulty is that it is not well understood which

parameters the buffing does depend on. This results appreciable loss of nearly finished (but inoperative) product and loss of through-put.

Materials modified by exposure to Ultra Violet (UV) light are under development. There are some technical difficulties associated with the UV exposure. Achieving and controlling pre-tilt has not yet been well demonstrated in such systems. The chemical reactivity of the starting materials as well as the reactivity of the final structures is a difficulty. However, patterning the direction of the alignment is more easily accomplished by utilizing the UV method.

Langmuir-Blodgett (L-B) films are also under development. However, there is no clear evidence that this can be done sufficiently quickly and reproducibly for a commercially viable manufacturing process. There are also severe cleanliness issues which are of concern in connection with the production of L-B films.

Obliquely evaporated silicon dioxide films are old, expensive technologies. They require rather good vacuums, slow and expensive evaporators, and are not currently used extensively in industry.

Other processes for producing aligned liquid crystal displays are disclosed in the following U.S. patents:

Harsch (U.S. Patent No. 3,941,901) disclose a surface alignment method for liquid crystal cells. The method of Harsch comprises applying to the surfaces of transparent plates bounding a liquid crystal film, a long chain polymer such as polyvinyl alcohol or polyvinyl butyral, which is subjected to a shear thinning technique to cause elongation and alignment of these long chain polymers. The polymers used by Harsch are non-rigid, non-ionic polymers.

Omeis et al. (U.S. Patent No. 5,247,377) relates to a process for producing thin, anisotropic layers composed of liquid crystalline substances. The liquid

crystalline substances are applied in a thin layer to one side of a support having a surface restructured in such a way that the structure is given a preferred direction which determines orientation of the liquid crystalline substance and data storage devices produced.

Various compositions are used to prepare liquid crystal displays. For example, Ahne et al. (U.S. Patent No. 4,619,500) relates to a method for producing orientation layers for liquid crystal displays wherein a solution of an organic prepolymer of polyoxozoles, polythiazoles, polyimidazoles, polyoxazinones, polyoxazine diones or polyquinoxalines is applied to a transparent substrate and subsequently annealed and subjected to an orientation treatment. Such orientation treatments include buffing.

Coates et al. (U.S. Patent No. 5,426,009) relates to a polymeric composite material which is based on a liquid crystal polymer component. The polymeric composite of Coates exhibits a high glass transition temperature of at least 60°C and a scattering texture when deposited as a thin film. The polymeric composites of Coates can be rendered transparent by being heated above the glass transition temperature and/or clearing temperature. The polymeric composites of Coates are obtained by mixing a liquid crystal polymer component, a reactive liquid crystalline component, optionally a polymerization initiator component, and/or further additive components, with subsequent polymerization.

However, up to the present time, it has not been known to utilize a rigid-rod poly(ionomer) composition in a buff-free alignment process to produce a liquid crystal display device having planar alignment and pretilt.

Summary of the Invention

The present invention concerns a composition and method for coating rigid-rod poly(ionomers)

directionally on charged surfaces resulting in the formation of liquid crystal display surfaces with planar alignment and pretilt.

More specifically, this invention relates to a process and class of materials for applying such liquid crystal alignment layers. It consists of applying a dilute, solution of a rigid-rod poly(ionomer) and a low molecular weight ion with the opposite charge, to the surface of an electrode using a directional coating technique such as meniscus coating, capillary action, brushing, or drawing the solution over the surface directionally using a rubber wiper or "squeegee" (doctor bar).

Alternatively, a basic or acidic ionizable rigid-rod polymer dissolved in a solvent of appropriate acidity so that the resultant rigid-rod polymer is charged, may also be used.

Accordingly, an object of the present invention is to provide a buff-free method of producing liquid crystal display devices having acceptable planar alignment and pretilt.

Advantages of utilizing the present rigid-rod poly(ionomer) composition and coating technique compared to the buffing technique of the prior art include, but are not limited to, those set forth below.

A first advantage is that the present process is less invasive in that the polymeric material is added to the electrode surface compared to removal through buffing.

A further advantage of the present process is that the process is cleaner, in that many devices utilizing the technology of the present invention must be manufactured primarily in clean rooms.

Another advantage is that the present process can be performed within the storage and operating temperature of most liquid crystal devices. Prior art polyimides, for example, require a "bake" at an order of

150°C which is outside normal LCD operating and storage temperatures.

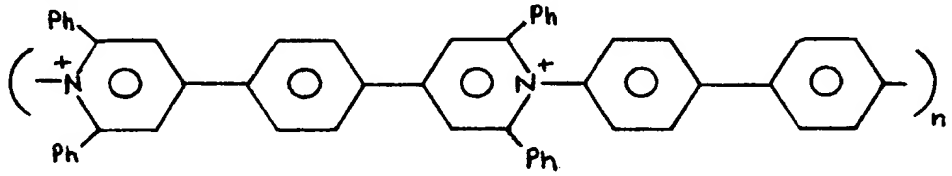
Other advantages and benefits of the invention will become apparent to those skilled in the art upon reading and understanding the following detailed description of the preferred embodiments.

Brief Description of the Drawing

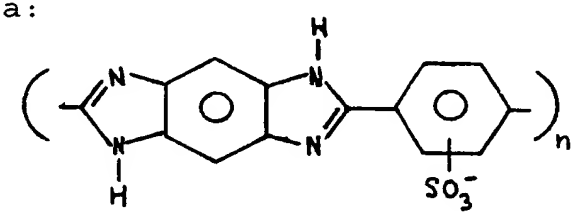
The Figure is a depiction of the process of the invention utilizing a "squeegee" apparatus to apply the rigid-rod poly(ionomer) alignment solution to a glass surface.

Detailed Description of the Preferred Embodiments

Many rigid rod polyionomers are known. A variety of proteins, the polysaccharide xanthan gum and other biological products are essentially rigid rods and have ionic or ionizable moieties attached. There are also synthetic materials such as positively charged poly(pyridinium) salts having the following formula:



wherein the intrinsic viscosity is in excess of 5, and negatively charged poly(benzimidazole - sulfonates) of the formula:



wherein the intrinsic viscosity is in excess of 3.

Each of these synthetic polymers is made by polycondensation reactions. Therefore, structural modifications and the formation of co-polymers should be

well within the ordinary skills of those practicing in the art. Structural modification of rigid-rod poly(ionomers) will permit small changes in pretilt to be achieved in various conditions. It is expected that polyionomers with larger optical polarizabilities along the long axis of the polymer will be superior to polymers without this character for "typical" systems in which the nematic has positive birefringence as this will favor the proposed alignment.

Most liquid crystal display surfaces contain or can be engineered to contain positively or negatively charged ions. The surfaces of glass and indium tin oxide (ITO) generally have "dangling bonds" consisting of negatively charged oxygens which will typically have a hydrogen ion associated with them. However, this hydrogen ion can be easily removed by washing in a weak base. Other surfaces, for example metals and other metal oxides, often have such exposed ions as well. Organic surfaces (e.g. polystyrene surfaces) often do not have such exposed ions (or only a few). However organic surfaces can generally be modified so as to have a number of such exposed ions. For example, a copolymer of styrene and styrene sulfonate will have exposed sulfonate ions on the surface; the addition of a dicarboxylic acid to a polyamic acid prior to heating to drive off water and form a polyimide will result in exposed carboxylic acid ions. Thus many surfaces can be made to have charges chemically bonded thereto. These charged surfaces can then bind oppositely charged polymers such as the rigid-rod poly(ionomers) of the present invention. This will generally result in a surface with the opposite charge of the original base surface which can then again be coated with another polyionomer having an opposite charge. Thus, it is possible to make multi-layered rigid-rod poly(ionomer) coatings on many surfaces.

It is important in a variety of liquid crystal devices to have surfaces coated directionally so that when materials in various liquid crystalline phases are next to the surface they will have specific directions relative to the surface. One important such alignment is a homogeneous planar alignment in which the direction of a nematic liquid crystal phase (which has as its only order a uniaxial alignment of the molecules) aligns close to the surface in a single direction which is close to being in the plane of the surface. The angle which this direction makes to the plane of the surface is important to the operation of many devices and is called the "pre-tilt". This alignment is also important in a variety of devices using smectic C liquid crystals (specifically those based on Clark-Lagerwald cells) as such planar alignment of a nematic is important in the formation of the ultimate alignment of the smectic C liquid crystal. There are additional constraints on the alignment layers in the smectic C phase in such devices, specifically that a "pre-tilted book-shelf" alignment form in the smectic C phase and that there not be a large energy difference between the two different states with polarization toward and away from the surface.

In order to achieve planar alignment with a definite pre-tilt, it is necessary to have a single direction application of the poly(ionomer) composition involved in the coating process. The coating process of the present invention can be practiced with a variety of single direction applicators and techniques, including brushes, meniscus coating techniques, capillary action coating, spraying, and coating with a semi-flexible rubber sheet or "squeegee".

In practicing the coating process according to the present invention, the rigid-rod poly(ionomers) are generally dissolved in an appropriate aprotic polar solvent such as dimethylsulfoxide (DMSO) or water. The

solute is present in a range of from about .005 wt. percent to about .02 wt. percent.

As a final step in the process of the present invention, drying of the coated poly(ionomer) film is essential to remove any excess solvent. Improved results are achieved as the drying time is reduced.

The following example demonstrates coating of rigid-rod poly(ionomers) onto transparent electrode surfaces to form liquid crystal cells using the process of the present invention.

Example 1

In this example, a squeegee was cut to have two sharp angles (approximately 90 degrees) on the side which was designed to engage the surface being coated. The specific coating apparatus is shown in the Figure. The surface being coated was negatively charged ITO coated glass which was cleaned prior to polymer coating. The ITO coated glass was placed horizontally on a hot plate and the hot plate was maintained at a temperature of approximately 60°C. The glass surface was then coated with a solution of poly(pyridinium) salt dissolved in dimethylsulfoxide (DMSO). The squeegee was then brought into contact with the poly(pyridinium) coated surface and drawn across it at a velocity of approximately one mm/second. The downward force on the squeegee was adjusted so that there was a film several microns thick (as observed by optic interference fringes) directly behind the squeegee during the process. The solvent was then allowed to evaporate. The quality of alignment was ascertained by constructing standard liquid crystal cells of approximately 12 microns in thickness with the coating directions of the two substrates aligned anti-parallel, examining the optical properties of both the cell of the present invention and a standard rubbed polyimide cell under a polarized microscope and comparing the alignment of the

cell prepared by the present inventions process to that of the standard cell.

The cell prepared by drawing the squeegee across the rigid-rod poly(ionomer) coated surface one time had reasonable alignment. Further tests have shown that drawing the squeegee across a second or third time with a small amount of the polymer solution in front of the squeegee produced very good alignment.

Use of a chiral polyionomer changes the symmetry of the coated surface. If the coating material is non-chiral then the properties of the surface are unchanged when it is reflected through a plane including the plane normal to the surface and the coating direction. If the system is chiral, no such symmetry exists. In the presence of a mirror plane the alignment direction of the liquid crystal must either be in the mirror plane (observed) or have two degenerate directions which are mirror images through this plane (not yet observed). If there is no such symmetry then the alignment direction is not constrained and can have any relation to the coating direction. A chiral material, xanthan gum, dissolved in water has been applied to ITO coated glass using a brush or squeegee. Good alignment of the liquid crystal is observed at an angle (15 degrees) to the brushing direction. This angle will be proportional to the enantiomeric excess. Such predictable and controllable angular changes of the alignment direction to the coating direction are useful in some applications.

Excellent alignment has been achieved by coating ITO coated glass using a brush and either (i) a poly(pyridinium) salt dissolved in DMSO or (ii) xanthan gum dissolved in water. The coating was performed by brushing the poly(ionomer) coated surface several times at a rate of approximately one mm/second. The surface is brushed first in one direction and then in the opposite direction. The brush should be displaced

perpendicular to the brushing direction between successive brushings. The direction of alignment and pre-tilt are controlled by the direction of the final brushing. As a final drying step, the solvent is allowed to evaporate.

Thermal stability is important in the manufacture of liquid crystal cells. Liquid crystal surfaces prepared according to the present invention have been exposed to temperature of 150-160°C for fifteen to twenty minutes with no apparent degradation of alignment. Visual observation, in fact, suggests some improvement on heat treatment. Similarly, treatment of the surface after coating with solvents may be important in manufacturing. We have verified that washing the surface with the solvents in which the polymers dissolve does not significantly degrade the alignment properties of the surface. Some liquid crystal devices require two different alignment layers (e.g. a homeotropic alignment) (alignment normal to the surface) and a planar alignment with pretilt, as achieved using our surfaces. We have prepared such a cell. It shows the expected alignment. A cell prepared using a squeegee and poly(pyridinium) salt in DMSO was characterized as having pretilt between 0.5 and 1 degrees, which is within the range of industrially interesting pretilts.

The invention has been described with reference to the preferred embodiments. Obviously, modifications and alterations will occur to others upon reading and understanding the preceding detailed description. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

Having thus described the invention, it is claimed:

1. A coating composition for attaining buff-free alignment of liquid crystals on a liquid crystal display device, the coating composition comprising a positively or negatively charged rigid-rod poly(ionomer) or salt thereof, with (i) a low molecular weight counter-ion or (ii) a basic or acidic ionizable rigid-rod polymer, and a solvent which is capable of dissolving the rigid-rod poly(ionomer) or salt thereof.

2. A coating composition of claim 1 wherein the positively or negatively charged rigid-rod poly(ionomer) is a positively or negatively charged heterocyclic rigid-rod poly(ionomer) or salt thereof.

3. The coating composition of claim 2 wherein the heterocyclic rigid-rod poly(ionomer) is an N-substituted heterocyclic rigid-rod poly(ionomer).

4. The coating composition of claim 2 wherein the heterocyclic rigid-rod poly(ionomer) is a positively charged poly(pyridinium) salt.

5. The coating composition of claim 2 wherein the heterocyclic rigid-rod poly(ionomer) is a negatively charged poly(benzimidazole-sulfonate) or salt thereof.

6. The coating composition of claim 1 wherein the rigid-rod poly(ionomer) is xanthan gum.

7. The coating composition of claim 1 wherein the solvent is a polar aprotic solvent.

8. The coating composition of claim 1 wherein solvent is water or dimethylsulfoxide (DMSO).

9. The coating composition of claim 4 wherein DMSO is utilized as a solvent for the positively charged poly(pyridinium) salt.

10. The process for manufacturing a buff-free liquid crystal display with planar alignment which comprises applying the composition of claim 1 to an oppositely charged surface of an electrode, followed by a drying step wherein the application step causes the axes of the rigid-rod poly(ionomers) to align in a planar direction with pretilt.

11. The process of claim 10 wherein the rigid-rod poly(ionomer) is a salt of a heterocyclic rigid-rod poly(ionomer).

12. The process of claim 11 wherein the heterocyclic rigid-rod poly(ionomer) is a positively charged poly(pyridinium) salt.

13. A process of claim 11 wherein the heterocyclic rigid-rod poly(ionomer) is a negatively charged poly(benzimidazole-sulfonate) salt.

14. The process of claim 10 wherein the rigid-rod poly(ionomer) is xanthan gum.

15. The process of claim 10 wherein the application step is accomplished by a squeegee.

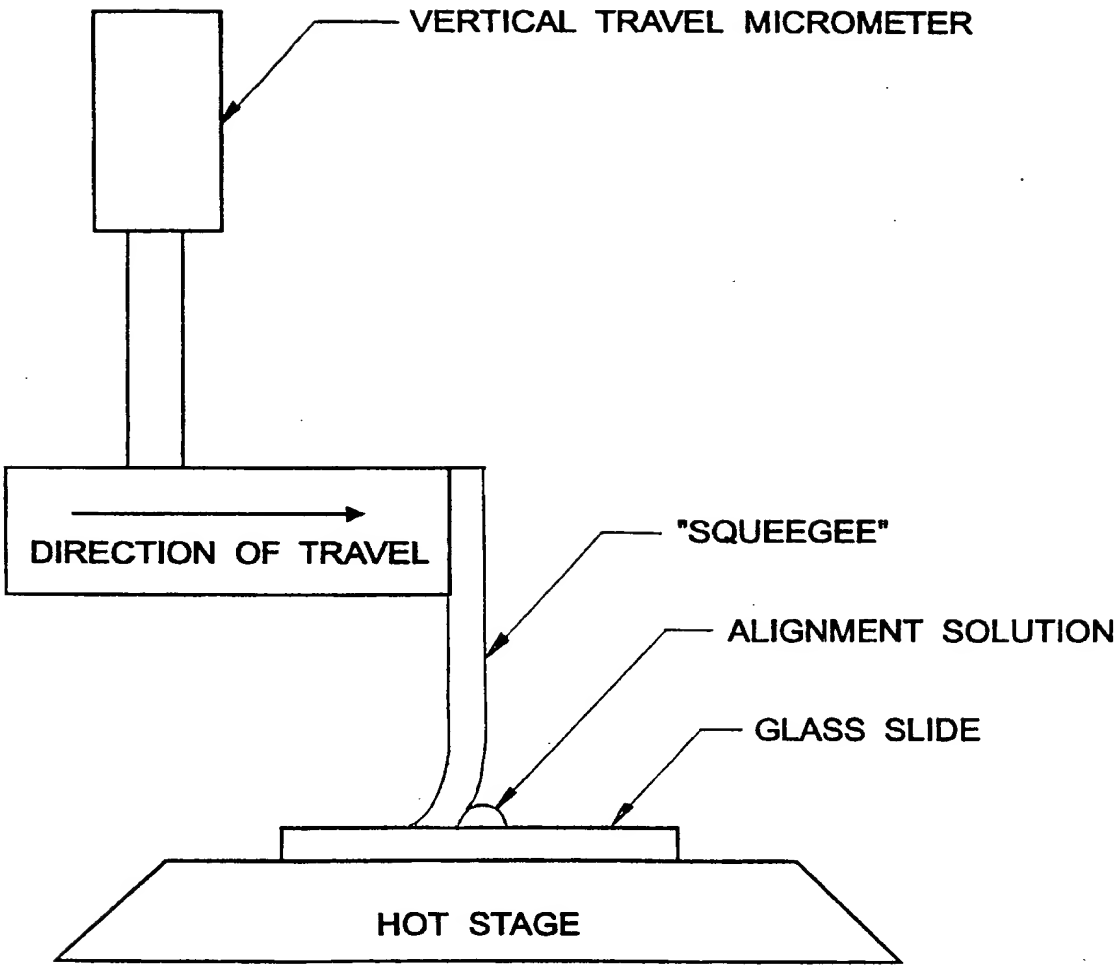
16. The process of claim 10 wherein the application step is accomplished by brushing, spraying, capillary action or meniscus coating.

17. The process of claim 10 wherein the charged transparent electrode surface is glass or indium tin oxide (ITO) having a negative charge.

18. The process of claim 17 wherein a poly(pyridinium), dissolved in DMSO with a counter-ion, is coated by a squeegee onto the negatively charged glass or ITO surface.

19. The process for manufacturing a buff-free liquid crystal display having planar alignment and pretilt which comprises application of a positively charged rigid-rod poly(ionomer) or salt thereof dissolved in a solvent, said application being by a squeegee, to a transparent negatively charged glass or indium tin oxide (ITO) electrode surface followed by a drying step wherein the application via squeegee causes the axes of the rigid-rod poly(ionomer) to align in a planar direction with pretilt.

20. The process of claim 19 wherein the rigid-rod poly(ionomer) is poly(pyridinium) salt and the solvent is dimethylsulfoxide (DMSO).


VERTICAL TRAVEL MICROMETER
DIRECTION OF TRAVEL
"SQUEEGEE"
ALIGNMENT SOLUTION
GLASS SLIDE
HOT STAGE

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/01195

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :Please See Extra Sheet.
US CL :252/299.4, 299.01; 428/1

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 252/299.4, 299.01; 428/1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4,068,923 A (TOIDA) 17 January 1978 (17-01-78).	1-20
A	US 4,965,017 A (HOLMES ET AL) 23 October 1990 (23-10-90).	1-20
Y,P	US 5,639,398 A (RHEE ET AL) 17 June 1997 (17-06-97), column 3, lines 50-58, column 5, lines 1-60.	1, 9, 10, 16, 17

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 07 APRIL 1998	Date of mailing of the international search report 0 7 MAY 1998
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer CYNTHIA H. KELLY Telephone No. (703) 308-0661

Form PCT/ISA/210 (second sheet)(July 1992)★

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/01195

A. CLASSIFICATION OF SUBJECT MATTER:
IPC (6):

C09K 19/56, 19/52, 19/00